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GLOBAL BIOPROGRESSIVE REHABILITATION PROGRAM AND POSTURAL INSTABILITY IN PARKINSON'S DISEASE

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Abstract

Postural instability increases the risk of falling. Falls are common events in Parkinson disease (PD) but only a few prospective studies have focused on causes and consequences of falls. Frequent falls represent a major problem for PD patients, causing head traumas and bone fractures. Different rehabilitative strategies have been tentatively applied, especially on visual disturbances, but more structured studies are needed to quantify the efficacy of specific physical treatments.

Objective: To create a bioprogressive rehabilitation program effective to influence in a positive way the quality of life through the recovery of postural control, the use by the patient of a more stable scheme of walking and less demanding from the point of view of the energy necessary, a raise of the muscular strength and resistance and a raise of the mobility. Ultimately the goal is to reduce the risk of falling and the spiral of events linked to the hypokinetic syndrome that can follow the event fall.

Methods: 12 PD patients were randomly selected. The patients underwent dynamic antigravity postural system (SPAD) associated with an auditory cue system (a metronome) and the high-intensity focused vibratory system (VISS) and VRRS (*Virtual Reality Rehabilitation System, active stretching* treatments for 4 months.

Results: The bioprogressive rehabilitation program has determined an improvement of balance of the patients while walking so a reduction of fall and an improvement in quality of life.

Keywords: Parkinson's disease, postural instability, rehabilitation, cues

Introduction

The interest for a therapeutic approach to the rehabilitation of Parkinson disorders related to movement, posture, gait and, therefore, the independence and quality of life of patients and their caregivers, stems from the evidence that these disorders, despite drug therapy, persist and worsen with the evolution of disease.

PD patients have impaired neurophysiological integration processes, especially of proprioceptive signals needed to form an internal representation of body movements and to implement compensatory measures in response to postural perturbations or external conditions that affect balance.

Movement disorders can severely impair the patient's autonomy, such as the ability to: walk, write, go up and get out of bed until you get the ability to live independently.

Characteristic symptoms include bradykinesia, akinesia,, phenomena of freezing , loss of balance and postural control (difficulty to maintain the upright position for hypotonia and reduced elasticity of trunk muscles and loss of balance when changing from one position to another and especially with eyes closed), stiffness and finally motor programming deficit.

This explains the postural instability and changes in gait characteristics ("stopped postures," camptocormia and freezing) that increase the risk of falling.

Bioprogressive postural rehabilitation program aim to achieve better neuro-musculo-skeletal conditions (strength, resistance, coordination), but also better overall motoric performances (postural steps, walk, daily activities) so the reduction of the risks of falling.

The therapeutic approaches are muscular stretching and training, the re-education of the postural steps, instability posture and gait, and the training for cognitive strategies such as auditory cues.

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The study has been developed at the Department of Physical and Rehabiltative Medecine of the University “G. D'Annunzio” in Chieti.

The sample was composed by 12 patients, 5 female and 7 males, with an average age of ± 64 years old, affected by Parkinson Disease.

The patients were involved in a drug therapy based solely on dopaminergic drugs or on dopamine agonists. In fact, they were not presenting any concurrent pathology.

Volunteers were eligible to participate if they were aged ≥ 45 years of age and ≤ 80 years of age and they fulfilled United Kingdom Parkinson’s Disease Society Brain Bank clinical diagnostic criteria for PD, their Mini-Mental State Examination (MMSE) scores was scores was ≥24 and Hoehn-Yahr stage > 1 and < 4.

Participants were excluded if they had symptoms and compatible signs with atypical parkinsonism; if they had positive history for major surgeries to the spine (tumors, infections, ankylosing spondylitis, paraneoplastic syndromes) or they suffered of other neurological diseases, respiratory diseases, cardiovascular diseases, severe cerebrovascular disease, diseases of the endocrine system.

The aim of the study was to improve postural control, the use by the patient of a gait cycle more stable and less expensive in terms of muscle energy, an increase in the muscular strenght and resistance so reduce the risk of falling and the spiral of events linked to the hypokinetic syndrome that can follow the event fall. Hypokinetic syndrome can result in the complete loss of autonomy and other comorbidities (reduction of respiratory and cardiovascular parameters, dehydration, incontinence, and ulcers) and finally death.

All the patients were included in a global bioprogressive rehabilitation program that can be summarized as follows:

-Pathophysiology of pain and Semiotics

-Preserve the homeostasis of cybernetic body system

-Posture linked with laws of balance, comfort and economy through the Rehabilitation Process and optimization of performance

- Movement Centralization

Rehabilitation Program consists in a global therapeutic approach made up of rehabilitation in microgravity environment with SPAD system for proprioceptive rieducation of posture and gait cycle associated with auditory cues and a specific and individual training program with whole body vibration and high intensity focused acoustic waves (ViSS) , active stretching and VRRS (*Virtual Reality Rehabilitation System*) treatments for 4 months.

- SPAD (Dynamic Antigravitational Postural System*),* 20 minutes, two times per week for 4 months. The Dynamic Antigravitational Postural System (SPAD) is a system of remission of body weight consists of a system to which the patient is connected via a harness: a belt worn to the height of the trunk, adapted to the individual characteristics of the patient, is then connected to the lift system by means of 4 belts attached to the body and to the pelvic girdle.

The system consists of a treadmill on which the patient performs the gait cycle retraing.

The system consists also of two rear bearings support placed one at the apex and a sacral infrascapular bearings and an additional 4 front, 2 height of the anterior superior iliac spines (SIAS) and the other 2 for the conjugations of the acromion-clavicular, which act as stabilizers-informants proprioceptive and prevent possible twisting of the pelvis or shoulder during movement on the treadmill. It allows to work in a three dimensional way on the posture correcting the asymmetries in a microgravitary and dynamic environment, thanks to the presence of treadmill at the base of it. The Treadmill is able to work at very low speed (0.01 Km/h) and it allows small speed increases. While training, each patient was followed by one physician and physical therapists and it has been invited to walk so composed and aligned. He has been facilitated by the sling and proprioceptive stimulation of the bearings, to make strides as long as possible, according to their ability, and it is correct continuously performing step, inviting the patient to get a cadence ordered sequentially with support of the calcaneus -plant-toe. The last part of the session has provided for the progressive reduction of the weigth body supported in a gradual way down to 0% and then the speed of the treadmill was reduced down to 0 km / h. In this way, the last part of the session, while maintaining the stimulus proprioceptive, to walk without weigth body supported.

SPAD system has been associated with an auditory cue represented by a metronome with sound that marked the rhythm of gait of the patient.

- ViSS (Vibration Sound System, BIOELCOM .s.r.l.), 3 sessions/week (15 min) for 4 months. Adaptive metabolic and mechanical responses of the human neuromuscular apparatus subjected to mechanical acoustic vibrations (MAV) are widely supported in the literature (Lundeberg et al., 1984; Seidel 1988; Tanaka et al., 2003; Saggini et al., 2006). These vibrations applied to muscle bellies and tendons cause the “vibration tonic reflex” characterized by an improvement in power contraction of the stimulated muscles. Adaptations caused by the vibration tonic reflex involve particularly the superior motor centers of the neuromuscular apparatus (Pasetti & Ferriero, 2008). These responses are characterized by an improvement in the neural stimulation that permits recruitment of a wider number of muscular fibers. The high-intensity focused vibratory stimulation has been shown capable of increasing the strength and muscular endurance. The ViSS is a is a multi-frequency system which reaches 300Hz and an amplitude of 200 mbar which uses focalized mecchanic-sound vibrations. The treated muscles in our study were: the rectus femoris, vastus medialis and lateral abdominal and back muscles, the glutes, the tibialis anterior muscle and the plantar fascia.

- Active stretching 2 sessions/week (10 min) for 4 months, particularly involving the extensor muscles.

- VRRS (*Virtual Reality Rehabilitation System*, *Khymeya Padova)* 2 session/week for 4 months. The VRRS used in the protocol is derived from a method of treatment in neuromotor virtual environment, using the most advanced knowledge of the neurophysiological processes of learning, centralitation and memory of the movement. It has been long proved that, through the rehabilitation in a virtual environment, the central nervous system receives feedback signals increased (augmented feedback) which, during the execution of voluntary movements, even if altered by the disease, induces profound changes in cortical and subcortical at the cellular and synaptic, increase knowledge and awareness of its performance with an improvement in motor activity. Technically, the VRRS generates a weak magnetic field consistent, inside which are recognized in real time the position and the inclination of small position sensors passive 3D, completely harmless. These sensors, which are applied to the affected part of the patient, or to objects of daily use, allow you to play within advanced virtual scenarios, the movements made by the patient, who is asked to imitate in real time the movement ideal pre- registered by the therapist. The sensors can reproduce objects, individual segments or the entire body of the patient, allowing the most various rehabilitation approaches, including those more complex such as walking, balance, compensation, as well as issues of cognitive order.

Activating the mode of "Interaction Dynamics ", you are allowing the patient to interact with everyday objects, because of their specific properties such as weight, mass, elasticity, allowing you to perform exercises that replicate faithfully activities typical of everyday life.

Patients were clinically examined at baseline, every moths during the 4-months treatment, and at 1 month after the end of treatment.

The series of test involved:

Two different types of digital measurement have been used. They are:

- Digital biometrics called D.B.I.S (Digital Biometry Images Scanning) (Diasu, Roma, Italy);

The use of digital biometric measurements has allowed mainly the observation of structural characteristics of the human body: biometric examination allows a thourough study of body structure (morphological investigation related to baropodometry static), the motor function (baropodometry dynamic) and receptor activity (stabilometry). The morphological analysis allows to evaluate visually and to quantify numerically the possible asymmetries of a patient compared to the position of reference. The position is studied on three projections: frontal (anterior and posterior), sagittal (right and left side) and transverse (from the top).

-Myometry (Diagnostic Support, Roma, Italy) (Simons & Mense, 2003);

The myoton is a patented, portable (<0.5 kg), noninvasive method, to measure the mechanical properties of muscles: tone, elasticity and strength. The Tone is the mechanic tension in the muscle which cannot be diminished voluntarily. The Elasticity is the ability of the muscle to regain its initial shape after a mechanical alteration. It is an index of the health condition of the muscle. The Stiffness is the ability of the muscle to resist to changes in its shape by external forces, and it is linked to the resistance provoked by the antagonist muscles.

- Scale Assessment: Berg Balance Scale (BBS), Hoehn and Yahr Staging, Unified Parkinson’s Disease Rating Scale (UPDRS).

Statistical analysis

The data collected after each evaluation have been analyzed and compared through a statistical analysis, which has been elaborated using the Student Test modified for coupled samples. The value of significance has been setted on $p<0.05$.

Results

Stabilometry test after the treatment showed a significant improvement of the distribution of the load in percentage as compared to pre-treatment condition.

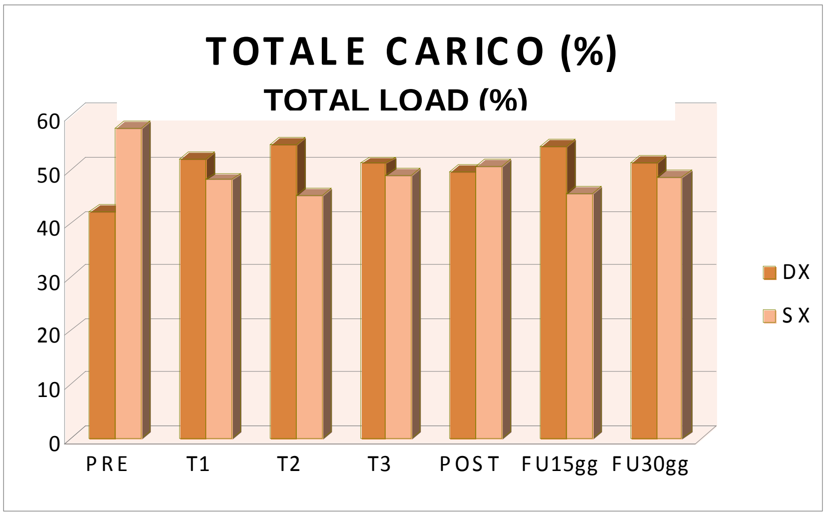


Fig.1 Total load

Statistical results on the total load (%) on covered by the foots showed a significant interaction between the side (right and left foot) and the evaluation session ($p < 0.01$).

During the treatment and after 15 days follow-up, the distribution of the total load was not different between the left and the right foot, indicating a better distribution of the body weight between the two hemisomata.

The morphological analysis allowed us to evaluate and quantify the possible asymmetries in a patient compared with the position of reference. An improvement of the relation between cervical, thoracic and lumbar arrows was evidenced, producing a better postural alignment of the patient, and a reduction of the dysmetria between the two hemisomata. In fact, the reduction of arrows ($p < 0.05$) showed a better postural alignment and a minor trunk anterior flexion, producing a better stability, thus contrasting the typical camptocormia (Litvan et al., 1996). This postural improvement persists also in the follow-up phase after 30 days ($p < 0.05$).

After the treatment is documented the reduction the sway area in all subjects ($p < 0.05$).(Fig.2)

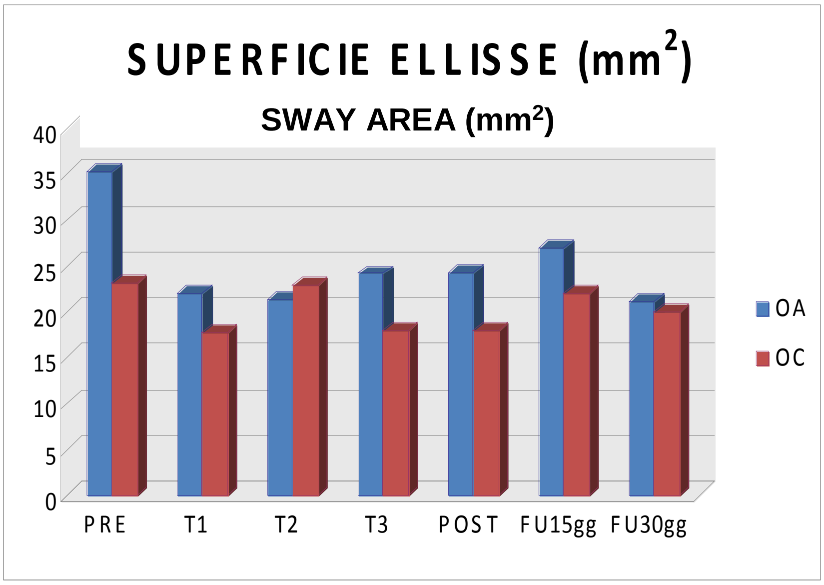


Fig.2 Sway area

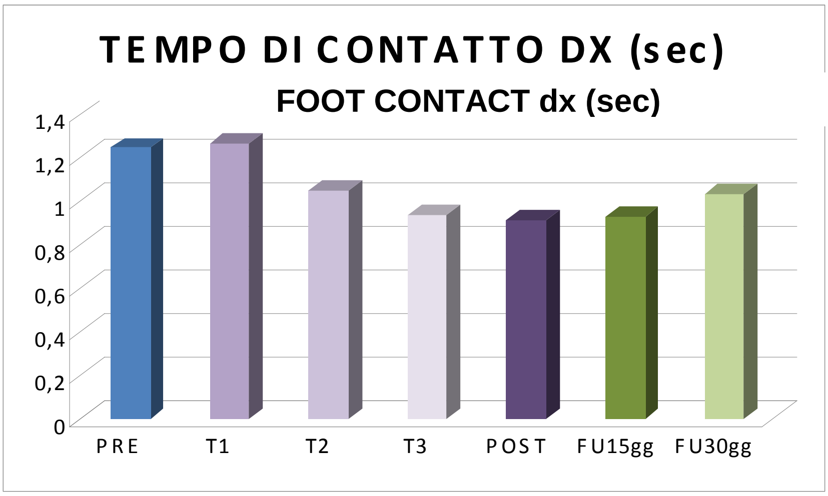


Fig.3 The time of the foot contact to the ground

Baropodometric dynamics showed a reduction of the time of the foot contact to the ground, with a consequent raise of the walking speed at the end of treatment (POST) as compared to baseline ($p = 0.02$), which persisted also in the follow-up phase ($p = 0.05$).(fig.3 and fig.4)

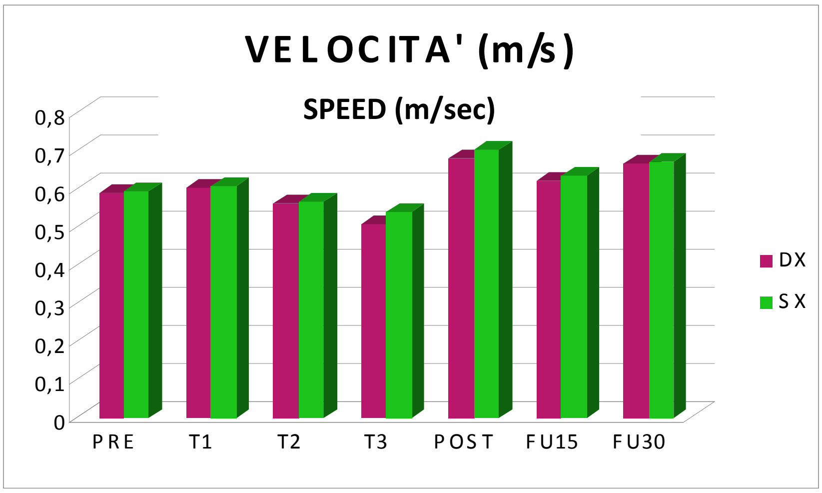


Fig.4 Raise of the walking speed

An increase of the semilength of the step (cm) during walking was evident by the end of treatment (POST) respect to the baseline ($p < 0.001$) and persisted at one month after the treatment ($p < 0.001$), highlighting a reduction of the base of support and consequently more stability.(fig 5)

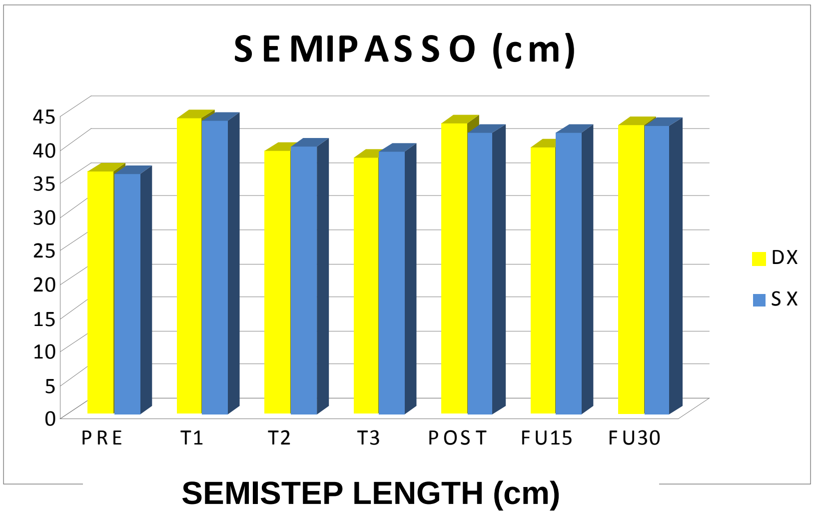


Fig.5 The increase of the semilength of the step (cm) during walking

The average pressure (gr/cm2) improved, due to a more balanced redistribution of the load between the two hemisomata ($p < 0,05$); as confirmed by the static baropodometry.(fig.6)

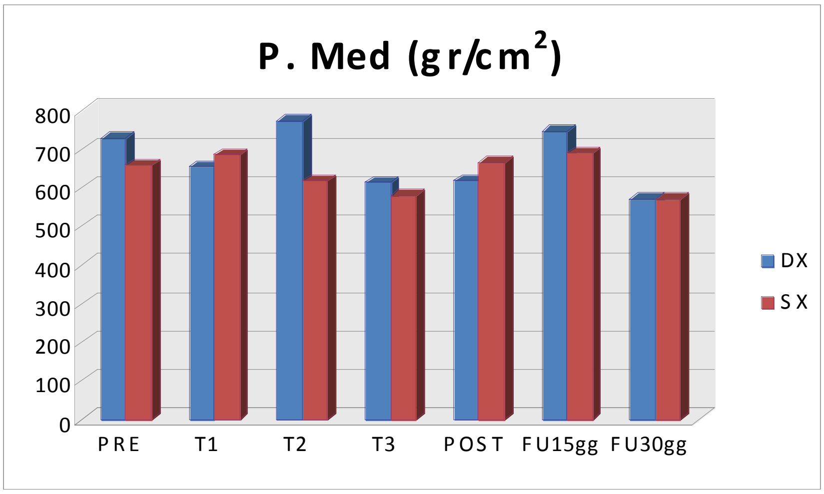
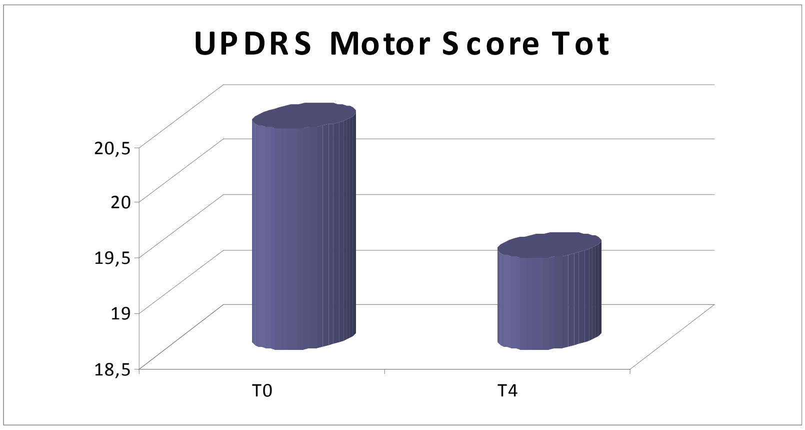


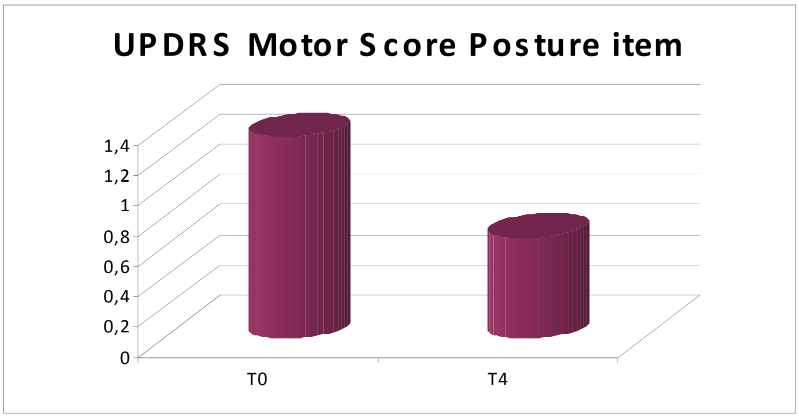
Fig.6 The average pressure (gr/cm2) between the two hemisomata during gait analysis

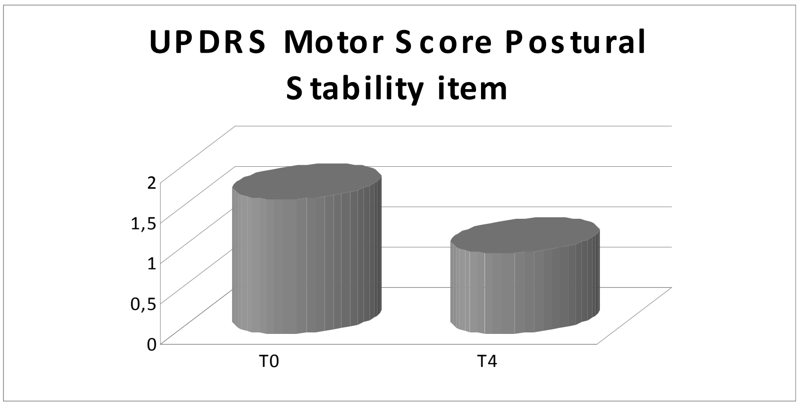
The muscular tone increased in rectus femoris, tibialis anterior and gluteus. The tone of biceps femoris decreased; this can be anyway considered positively, because the patient affected by Parkinsonism tends to use mainly flexor muscles of the leg (biceps femoris) to maintain the balance in standing position, contrarily to a healthy subject, who utilizes more the activation of extensor muscles of the leg (Dietz et al., 1993)

Berg Balance Scale (BBS) score varied from a 37.7±12.1 at the baseline to a score of 47,6±9.2 at the end of treatment ($p = 0.02$). The improvement in the score of the Berg Balance Scale showed an improvement in terms of balance and therefore a reduction in the risk of falling.

The results of the Unified Parkinson's Disease Rating Scale for a global evaluation of the patient (UPDRS) are the following:







Conclusion

Postural instability and risk of falling are two fundamental aspects with severely affect in the quality of life of patients with Parkinson's disease and, in such patients, it can be said that the rehabilitation treatment must be introduced early and may compensate for the lack of the pharmacological effects or integrate its.

PD patients have impaired neurophysiological integration processes, especially of proprioceptive signals needed to form an internal representation of body movements and to implement compensatory measures in response to postural perturbations or external conditions that affect balance.

The development of research in the use of strategies that can by pass these circuits deficit , in addition to the visual cues, including auditory stimulation to achieve a sort of re - training in patients Parkinson's disease.

The auditory cue can be the “beep” sound of a metronome or a song.

The auditory stimulation, in the form of Rhythmic Auditory Stimulation (SUR) has found increasing favor over the past 10 years and appears to be very promising therapeutic and, with it, the use of metronomes.

In several studies it was observed that PD patients were able to adjust their gait to a rhythmic pulse of 10 % faster than their reference values, significantly improving speed and stride length (Cunnington, 1995; McIntosh, 1994 & 1997).

The improvements were still evident in the immediate short term even in the absence of stimulation, and those patients who exercised daily with SUR, showed the most significant and enduring improvements in walking compared to those patients who performed the same exercise program without SUR. Execution of the movement in PD patients is not regular because they are not provided with adequate internal rhythmic stimuli (Phillips, 1994).

The protocol tested in this study showed, with its results, which is rehabilitation through the SPAD system associated with auditory cue, VISS and active streatching and VRRS (*Virtual Reality Rehabilitation System)* can improve posture and gait quality of patients with Parkinson's disease.

The greater stability improves the kinematic and kinetic characteristics of gait and lowers the risk of falls.

These results are derived to the fact that SPAD works by correcting the asymmetry of body and allows to modify the adjustments asymmetric gait, by means of a vertical movement of the center of gravity of the subject, sufficient to allow a more normal gait, appearance of fundamental importance in Parkinson. The system also works with a dual action, of mechanical type, allowing a retraining with neuromotor forms of learning cortico subcortical face to again a schema body in balance which minimizes the energy consumption necessary for the regaining of balance and posture and proprioceptive acting on maintaining the adaptations induced over time and related to automatic gait.

With Vibratory Stimulation (VISS) can reach frequencies of 300Hz. In this way, it may stimulate different receptors in muscle and skin is of a mechanical type that proprioceptive (Pacino corpuscles, Golgi tendon organs, mechanoreceptors of type II muscle spindle -IV), leading to a Long Term Potentiation (increase in strength of synaptic transmission with increase of neuronal plasticity), obtaining an increase in the contractile capacity, elasticity, and the recruitment of the fibers of the musculo-skeletal tissue, and ultimately improve the postural stability in PD patients.

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